The Emerging Roles of Industrial Engineers in Preventing Pollution and Creating a Sustainable Environment

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Abstract

This paper reviews the current debate over the potential role industrial engineers can have in preventing pollution caused by manufacturing processes and emphasizes how both disciplines can be combined to create efficient solutions. It introduces the expectations both industrial engineers and environmental engineers have within their professions as well as what is expected from them in terms of projects and goals. It outlines what is currently being done in order to control pollution within systems and how there needs to be a focus on how to prevent it at the source. It discusses how environmental engineers can benefit from industrial engineers in adopting certain ways of thinking and how combining skill sets could be beneficial to the bigger picture. The paper ends with proposed solutions in applying industrial engineering concepts to minimize waste by-products and leaves the door open to the creation of standardized programs that would benefit many businesses worldwide.

Key Words: Pollution Prevention, Environmental Engineering, Industrial Engineering, Waste, Control, Process Improvement, Process Design, Sustainability

1. Introduction

Environmental engineers have been struggling with the misconception that their primary role is to save the environment and clean up the messes we leave behind. That job description definitely puts a lot of pressure on the environmental engineer. A new concept has emerged that shifts a portion of this responsibility to industrial engineers, who are known to deal with removing wastes in processes to make systems more efficient.

What kinds of wastes are industrial engineers currently dealing with? They work to remove extra motion, process steps, waiting times, idle times, and wastes from a current system. Waste can generally be categorized in two separate categories: excess resource use and output waste. The latter is the most important waste to control because of its high negative effects on the environment [1]. Excess resource use just deals with the internal process steps, not necessarily producing tangible wastes. Industrial engineers are not usually concerned with the external waste that a process creates; they are focused on the internal wastes that prevent certain systems from operating at their full potential. Examples of external waste include excess paper in an office or waste chemicals from a paper pill. In discussions of the impact of the external waste on the environment, another debate arises regarding the general need to constrict the use of materials and energy in order to protect environmental systems [2] versus solely accomplishing this through technological innovation. This paper will explain the role of industrial engineers in preventing pollution through process and facility design, rather than having only environmental engineers controlling it. It will present solutions in which the consumption of materials and energy will not need to be constrained and in which pollution prevention does not solely rely on technological innovation; rather, the solutions will focus on redesigning and reevaluating the

way products are made, in order to decrease the amount of emissions and energy use that act as undesirable outcomes.

2. Current Pollution Prevention Methods

The situation with preventing pollution thus far has mostly been focused on its control rather than its prevention. There have been a handful of government regulations that have been composed for this purpose in hopes of creating some sort of standard with the way certain activities are addressed and implemented. The United States Environmental Protection Agency (EPA) is the main authority figure that ensures these acts are being followed and makes sure to hold those who disobey accountable. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Superfund Amendments and Reauthorization Act (SARA) both deal with overseeing toxic waste disposal activities and controlling those that have harmfully impacted the environment [3]. The Resource Conservation and Recovery Act (RCRA) also deals with controlling the methods of waste disposal in general. Unlike all of these pieces of legislation, there is one in particular which is very difficult to enforce: The Pollution Prevention Act (PPA). The PPA states that sources should act in preventing or reducing pollution whenever feasible. Although this act could not be successfully implemented, it allowed for other policies to come about that focused on recycling and unnecessary packaging.

Before any type of rectifying action can even begin, companies need motivation, besides being hit with a fine, to want to regulate their waste output. What is in it for them? Companies are actually required to provide extensive documentation of the wastes they generate. Pollution prevention methods can certainly save them a lot of time and money through decreased regulatory compliance and waste treatment costs if the wastes they generate were just cut in half. Pollution prevention also allows a company to minimize their future waste-disposal liability. According to SARA, a business can be held accountable for cleanup costs even if that company followed the correct waste disposal procedures [3]. Therefore, pollution prevention can reduce the cost a company would have to pay in the future.

Moving from the current state of pollution prevention to the ideal state requires a change in thinking and a change in the way certain processes are designed. Processes have been designed without any regard for waste; waste is seen as more of a by-product of the process than as something imbedded within it. Current state thinking calls for the environmental engineer to take the responsibility of handling these by-products after they are produced [3]. Ideal state thinking expresses the fact that businesses need to address pollution at the manufacturing process level by making small improvements using mechanical and chemical processes and minimizing the waste the process produces. This type of thinking would not be just the responsibility of the environmental engineer [4].

3. The Role of Environmental Engineers

Environmental engineering is an area of study whose applications have the potential to deal with process improvement and redesign, but not many people view this profession that way. To the masses, environmental engineering uses science and engineering tools to improve the

environment and to use the output wastes of one process as inputs of another (recycling) [5]. The method in which the environment is improved will distinguish one environmental engineer from the next. An environmental engineer who is able to test the waters of other disciplines allows for him or her to develop sustainable methods of improvement. The more comprehensive description of what an environmental engineer can do and how he or she has the ability to think can be described as providing a standard of living that is of quality for a growing population [5]. Environmental engineers also seek ways to minimize the impact that humans have on this planet by incorporating environmental and social constraints into designing different products. Environmental engineering focuses on the science of environmental sustainability [5].

Environmental engineers do have an advantage over industrial engineers in preventing pollution due to the vast learning curve that industrial engineers would need to overcome in the specific industry. Because environmental engineers have this knowledge, they can definitely benefit from an industrial engineer's way of thinking to design and build new pollution control systems/devices that would replace older ones [5]. Environmental engineers do a lot of monitoring and control of certain processes that harm the well-being of the environment, as well as many public health issues. An important concept to note here that will be further addressed in the next section is the difference between "control" and "prevention" and how these two engineering disciplines have been assigned those separate roles. A new way of thinking is emerging that refrains from looking at these two areas as completely separate disciplines and focuses on how they can each benefit from each other to develop a sustainable process to prevent pollution for businesses all over the globe.

4. The Industrial Engineer's Role

Industrial engineers are very process-focused and will analyze the current state of any system in order to accurately provide suggestions as to what process steps they can remove to make it as efficient as possible. They concern themselves with minimizing the cost of redesign as well as maximizing the quality and throughput of the system. Throughput is the amount of products that can get through the entire system per unit time. They usually do not concern themselves with the waste produced from these systems; it has been taken as a given to be dealt with by environmental engineers [3]. In the past, industries have spent a large amount of money creating different processes that deal with the control and treatment of the waste produced. To an industrial engineer, these actions are considered non-value-added because there need to be methods to prevent waste entirely rather than just to control it. Preventing pollution is a greater investment because if less of it exists, the amount of money that is used to control it decreases. In order to really get an understanding of this concept, think of antibiotics versus vaccines: antibiotics control illnesses while vaccines prevent them. Industrial engineers apply this concept each time they analyze a system and design a better way to improve it.

In regards to pollution prevention, industrial engineers can also practice this concept and develop ways to alter the sources of the waste, so that less is produced as a by-product. They will then have more of a role and responsibility for the production process and managing its products and wastes. Then, environmental engineers should be called when industrial engineers cannot prevent the wastes at their source [3]. The struggle with this way of thinking is questioning how far industrial engineers can go without monopolizing that area of focus. Are environmental

engineers ready and willing to accept this new role and allow industrial engineers to have more of a responsibility in preventing pollution? There will definitely need to be some realignment of occupational goals if this concept were to take flight, but there is a lot of potential in what can be done if these two disciplines figure out a way to join forces. Table 1 summarizes the differences between the two disciplines.

Environmental Engineering	Industrial Engineering
External Waste	Internal Waste
Methods of waste disposal	Methods of removing waste at the source
Waste Control	Waste prevention
Improve standard of living	Create standards to improve processes
Minimize impact humans have on environment	Minimize non-value-added activity

Table 1: Key points summarizing the major differences between environmental and industrial engineering

5. Pollution Prevention Solutions

Industrial engineers do have unique ways of solving problems and have researched different methods of pollution prevention where they could effectively apply their knowledge. The sections below describe how industrial engineers can play a role in preventing pollution and how they can effectively develop a sustainable process.

5.1 Facilities Planning

When designing a new facility, industrial engineers will have to ask the question, "How can this facility be designed so that its environmental impact can be at a minimum?" There are factors that need to be taken into account regarding facilities planning: space requirements and material handling requirements.

5.1.1 Space Requirements

It is crucial to have efficient flow of material and personnel in and out of departments because it will naturally decrease the waste produced by reducing energy consumption and possible work-in- progress (WIP) losses [4]. WIP can be described as products or material that are being worked on in the system but have yet to be completed. If a facility has too much space, there is

more of a chance that WIP will accumulate at a faster rate and will then result in waste downstream. The distance between different departments is also crucial when designing the layout because it will significantly reduce the flow of material and energy throughout the facility [4]. Aisles throughout a facility provide routes to which material travels; therefore, accurate aisle placement will reduce the amount of waste.

5.1.2 Material Handling

Material handling involves all of the actions taken to move raw materials or WIP within the facility. Engineers concentrate on what materials to move, how to move them, when to move them and where to move them to [4]. Material handling systems that are designed efficiently naturally minimize waste within the process and provide optimal workflow within the facility.

One aspect that can be improved through industrial engineering to minimize the external waste is the actual material that is handling the products. Usually, facilities will use cardboard boxes, weak wooden pallets, or shrink-wrap plastic that will all become waste after the process is complete. One solution would be to use a material that could be easily reused without the possibility of it damaging or deteriorating over time. Materials of this sort include metal or plastic bins that could replace the disposable packaging [4].

5.2 Total Quality Management

Total Quality Management (TQM) is a system that is used throughout the majority of manufacturing facilities and can also be applied to managing the effects of waste on the environment. TQM focuses on producing high quality products that have as close to zero defects as possible [6]. Those who implement TQM are concerned with whether each product meets the expectations of the customer, which is directly rooted in the level of quality. It is important to note the difference between TQM and inspection; quality is built within a product, not inspected into a product [6]. In order to fully understand TQM and how it can contribute to pollution prevention, two factors must be discussed: continuous improvement and strong management commitment.

5.2.1 Continuous Improvement

Engineers view continuous improvement with the goal of having zero defects in a product, or in this case, zero wastes produced by the system. They realize that it is almost impossible to achieve this perfect system; however, that is why continuous improvement is so important. It forces the industrial engineers to keep improving the process and making it better.

When TQM is applied to pollution prevention solutions, it is called Total Quality Environmental Management (TQEM) and introduces the method to prevent pollution wherever possible [6]. In order to do so, facilities need to focus on the customer, classify the wastes themselves, and analyze what steps need to be taken to minimize the amount of waste as much as possible. An important skill to have when analyzing a process is to perform a root cause analysis as well as produce a value stream map (VSM) of the current state of the process [1]. Value stream maps

(Figure 1) display the entire process flow as well as the durations of each step. VSM's are useful in identifying the gaps within a process and allows the problems to become visual.

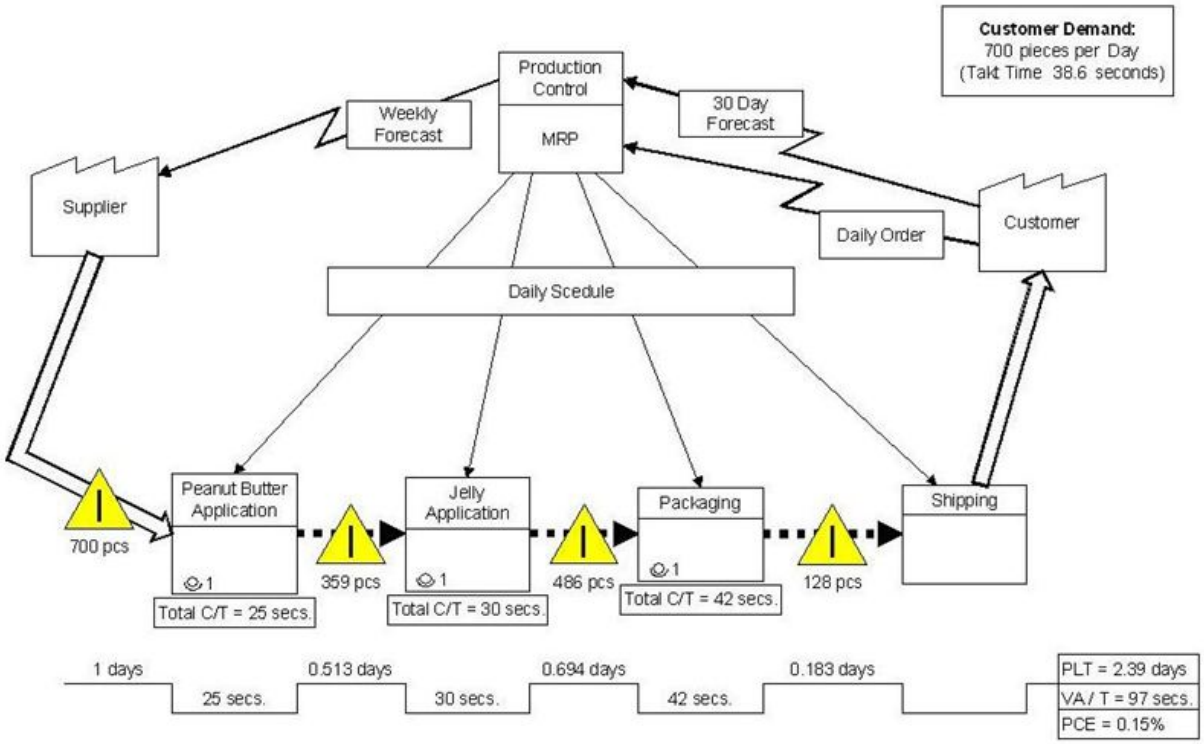

Figure 1: An example of a value stream map for a simple process [7]

If there is a specific problem that needs to be analyzed, the "Five-Why's" (Figure 2) is a tool used in order to perform a root cause analysis.

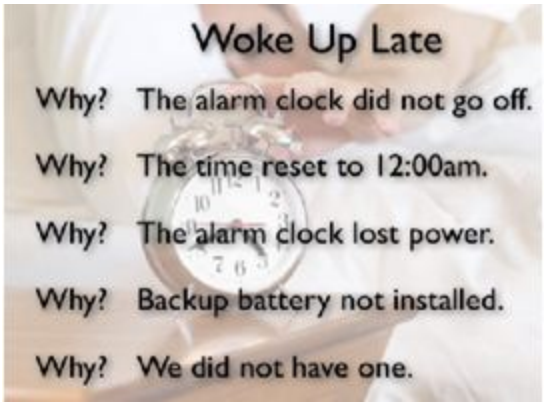

Figure 2: An example of the Five-Why method to perform a root cause analysis [8]

5.2.2 Strong Management Commitment

The success of TQM is directly related to the skills and level of commitment of those who are implementing it. The entire process allows employees to become very familiar with all aspects of the process. Because they are forced to analyze and consider process wastes, the quality of the product will benefit from this analysis and improvements will begin to take place.

No TQM or TEQM program will be able to succeed if higher management is not on board. Since they are the ones with the final say, it is important that they are brought into this process and are open to the idea of continuous improvement [6]. They must understand the reason behind using the root cause analysis as a tool to solve problems and to minimize the waste of the entire process. If a strong commitment from management does not exist, then the improvements will not be sustained and cleaner solutions will not be reached.

5.3 Process Design

Designing a new process to manufacture a certain product or perform a certain operation requires careful planning and resources. Incorporating industrial engineers into the process design to create an Ecologically Sustainable Organization (ESO) will benefit the business in reducing the amount of waste that acts as a by-product of the system [2]. This ideal state can be reached by limiting energy use and materials through product redesign, using renewable materials as much as possible and developing ecologically sensitive purchasing policies [2].

Redesigning a product such as a refrigerator requires certain process steps in order to seek out the desired improvements. It is known that refrigerators require a fraction of household energy to perform its functions; that energy consumption is also known to take a toll on the environment. For other products, the impact they have on the environment may not be so clear, but the first step is to evaluate the environmental implications of different materials for a certain product [9]. The next step is to obtain the right tools to implement this redesign. The types of tools will vary within each industry, but the overall purpose is the same: to develop environmentally preferable products.

Another concept to integrate into process and product redesign is Life Cycle Design. It is a structured approach to incorporate pollution prevention strategies into the development of ecologically sustainable products. The process begins with acquiring the raw materials and continues on through materials processing, manufacturing and assembly, use, and service and ends with disposal [10]. The goal of Life Cycle Design is to minimize the risks and impacts created from all of these process steps. Successful designs entail the balancing of environmental, cost, legal, performance and cultural requirements. The framework of the Life Cycle Design process is similar to the steps mentioned in the previous paragraph, but also emphasizes a specific environmental management program that must be implemented within a firm. The elements of the program that was developed at the Ford Motor Company are shown in Figure 3 below. After a solid environmental management system is developed, a needs analysis must be performed as well as specifications of design requirements. The design strategies will then be selected and synthesized for minimal environmental impact [11]. The bottom line to any type of improvement initiative is that it needs to be assessed to accurately identify the sources of waste that it exposes, what it can eliminate and what it fails to eliminate. The process needs to begin at the earliest phases of design [11].

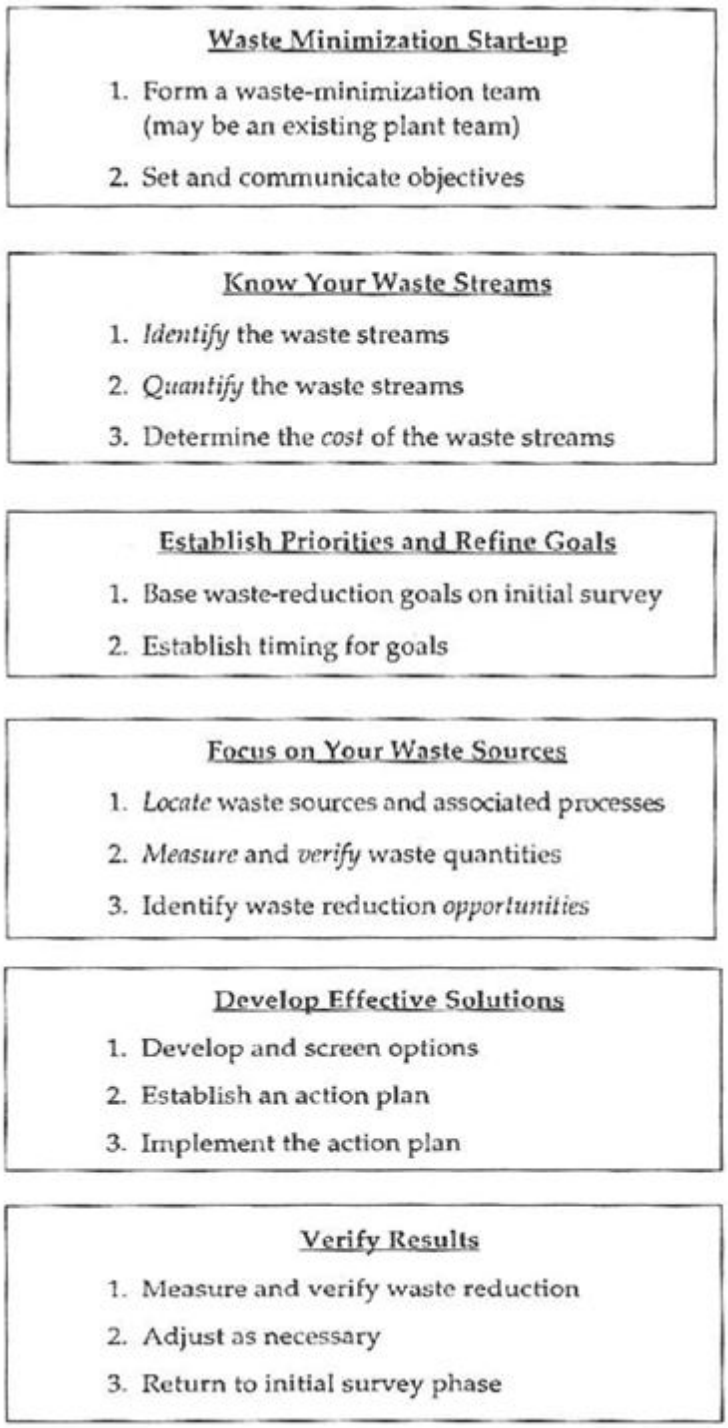

Figure 3: Elements to include in a waste prevention program [12]

6. Conclusion

This paper reviewed the different roles of industrial and environmental engineers emphasizing their responsibilities in developing solutions to prevent pollution. It introduced the idea that

pollution prevention should not be just the responsibility of the environmental engineer; rather, it should also be the responsibility of the industrial engineer because of the certain skill sets they possess and their unique way of thinking. Future research should be geared towards coming up with standards using industrial engineering concepts in order to prevent pollution – currently there are more suggestions for ways to apply the industrial engineering concepts to environmental problems. Few businesses have implemented this type of program and should be recognized more for their efforts. Pollution prevention does in fact need to be a combined effort with all types of engineering because it is such a complex issue. It requires knowledge of both environmental concepts and design principles that need to be utilized in the best way possible. Therefore, creating programs that focus on how to minimize the waste of a process is a solid first step in preventing pollution, and industrial engineers definitely need to be consulted every step of the way.

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